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A NEURAL NETWORK PROTOTYPE FOR PREDICTING F-14B STRAINS AT THE B.L. 10 LONGERON

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13. ABSTRACT *(Maximum 200 words)*

A neural network prototype was developed to predict strain from data obtained from an F-14 flight test program. Data from two flights were available: Flight 400 consisted of standard structural maneuvers, and Flight 401 consisted of maneuvers performed during typical fleet operations. Several variables were monitored during flight, including Nz, Mach number, altitude, wingsweep angle, roll rate, angle of attack, a weight-on-wheels indicator and the strain at B.L. 10 of the F-14B. The neural network was trained on Flight 400, and tested on Flight 401. A forward-stepwise-regression was also performed on Flight 400 and the selected model was tested on Flight 401, for comparison.
Results were evaluated by comparing the correlation coefficients between the predicted and measured strains. The correlation coefficient obtained by the neural network was 0.93 and by the regression equation was 0.94. Based on these preliminary results, the conclusion is made that the neural network approach offers a viable alternative to standard regression analysis for predicting strains on airframes.

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ABBREVIATIONS

ALT	Altitude
AOA	Angle of Attack
B.L.	Butt Line
DOS	Disk Operating System
MACHNO	Mach Number
Nz	Acceleration in the vertical direction
PC	Personal Computer
SEI	Systems & Electronics, Incorporated
SDRS	Structural Data Recording System

SYMBOLS

L	Indicator for Landing Record
P	Indicator of Peak Nz Record
T	Indicator for Take-off Record
V	Indicator for Valley Nz Record
True	Indicator for Weight-on-Wheels
False	Indicator for Weight-off-Wheels

INTRODUCTION

Neural networks offer a new tool for predicting strains of structural components at critical locations of an airframe. Frequently, strain response to loads occurring in flight are non-linear and difficult to calculate from sets of linear equations. Accurate load or strain equations at fatigue critical locations are sensitive to weight, stores, and geometry configurations. Neural networks can use flight variables as input to predict strains needed for fatigue life calculations. No traditional programming is needed, so there is no need to try to model the strain relationships. A well-trained network is good at generalizing from one set of conditions to another, which gives it a distinct advantage over a set of equations. The successful use of neural networks depends the availability of large amounts of data to train with. Data from the SEI (Systems & Electronics, Incorporated) F-14B SDRS (Structural Data Recording System) is available from a flight test aircraft and can be used to investigate the potential of neural networks to predict strain at critical locations on the airframe.

The purpose of this paper is to explore the potential of neural networks to calculate strains on fatigue-critical aircraft components. The B.L. 10 longeron located on the F-14B aircraft was selected as an example component to demonstrate the technique.

BACKGROUND

Neural networks are patterned after the human brain. Input neurons are selected and connected in the network and given facts to learn. Facts are input-output pairs. They can be numbers, words, or symbols. Neural networks learn by example and repetition, not programmed rules as with an artificial intelligence system. They are not encumbered by linear or non-linear equations; instead they are composed of an input layer, one or more hidden layers, and an output layer. The addition of the hidden layers provides the flexibility needed to make it a non-linear system, but are hardly ever needed. Figure 1 contains a diagram of a sample, feed-forward, neural network. Each neuron in a layer is connected to every neuron of the succeeding layer. In a feed-forward network, no neurons in the same layer are connected. Neural network software is readily available commercially. A software program which runs on a PC (386 machine) was used for this project [1].

Most neural network commercial software use a supervised learning scheme known as back propagation. Each input to a neuron has a connection strength. Initially, the connection strengths are set to random values. The network learns to fire

with sufficient strength to achieve a response which matches the output pattern. When it doesn't, the network makes corrections to itself by adjusting the connection strengths and goes over the entire list of facts again. The amount of adjustment to the connection strengths is determined by the magnitude of error and the setting of a parameter called the learning rate, which supplies stability to the learning process. A transfer function is applied to each neuron's activation value to generate each neuron's output. Neuron transfer functions usually take on values between 0 to 1. A sigmoid function is recommended because it is continuous and monotonic and its derivatives are continuous everywhere. The process is repeated until it gets all the facts correct. The more data it has to train on, the better it is at predicting new situations. The neural network will be better at generalizing if the training facts represent a broad range of experiences and responses.

The input for training the neural network using the reference software consisted of three files: the definition, fact, and test files [1]. The training facts were placed into the end of the definition file. The software randomly selected about 10% of the data to test later before it trained on the fact file. This percentage can be changed by the user.

The definition file contains a list of the input neurons, display attributes, and the maximum and minimum values of the input data which are used by the program to scale the input data into the range of the transfer function, typically 0 to 1. A smaller range of maximum and minimum values will improve the predictive ability of the network. Note that neural networks are very good at identifying trends in data, but they are not as good at precision. Like humans, they are better at picking up large numeric differences than small differences. The results of a neural network will be good to within a few percent of the right answer, given that it trained with a reasonable tolerance. The definition file also describes how many output neurons there are, what kind of data will be output, and attributes of the display. It also can contain the training facts. Training facts are the input data together with their output, with which the neural network uses to train.

The test file, like the training file, contains facts together with their corresponding output. The testing of the neural network involves testing the predicted output from the facts against the known output and reporting the number of good and bad matches according to a designated testing tolerance. The neural network does not adjust its connection strengths during testing, it merely reports the results. When the network has been trained satisfactorily, it can be used to make predictions with a running fact file. The running fact file is identical in format to the testing fact file, but contains only the input.

The trained network can be executed a few different ways. It can be run from within the neural network software. It can also

be run in the batch mode by anyone who has a copy of the software, either called from DOS (Disk Operating System) or from within another program. There is a third option to create an executable version of the network from a "C" source code, which could then be distributed as needed. These options involve running facts through the network in a feed-forward mode. No additional training or testing can be done in the batch mode.

A neural network works best when it is given a lot of information with which to train. It is not desirable to presuppose which variables the network will need to establish patterns. The neural network has a better ability than a human to recognize complex patterns among many variables, so it trains more quickly and better when it is supplied with all the available information and left to decide what is relevant. The relationship between the input and the output may be perceived to be non-linear by a human, but the neural network considers only what firing strength is needed to achieve the output pattern.

We decided to investigate the potential of neural networks by training one to predict strains on the F-14B airframe at the B.L. 10 longeron.

DESCRIPTION OF THE DATA

Flight test data were obtained from an instrumented F-14B aircraft (referred to as Aircraft #7) from the Grumman Corporation, Calverton, NY. In particular, SDRS data from Flights 400 and 401 were provided to the Navy on floppy disk. Flight 400 was composed of a series of "standard" structural maneuvers while Flight 401 was composed of maneuvers typical of fleet operations. A neural network was trained on Flight 400 and tested on Flight 401. These data were appropriate for neural network application because they included in-flight variables and the corresponding B.L. 10 strain. The measured variables included Nz, wingsweep angle, roll rate, Mach number, altitude, angle of attack, and a weight-on-wheels indicator, among others. Unfortunately, remaining fuel weight was not monitored, which would greatly increase the effectiveness of the neural network to predict strain. The angle of attack input appeared to compensate for the lack of weight information. In the future, weight should be monitored, to enhance the capability of the network to predict strains.

APPROACH

Flight test data from Flight 400 were used to train a neural network and perform a forward step-wise multiple regression analysis. The merit of the neural network approach was assessed by comparing the correlation between the predicted and the strain measured during Flight 401 to that achieved using the regression equation.

ANALYSIS

A training fact file was assembled from the data from Flight 400, which contained only the records which triggered on Nz peaks. These records produce the peak strains which cause fatigue damage. The input variables used for this analysis were Nz, wingsweep angle, angle of attack (AOA), roll rate, Mach number, altitude (ALT), a true-false indicator for weight-on-wheels (True or False), and an indicator for take-off, landing, peak or valley (T,L,P or V), for a total of six numeric neurons and six symbolic neurons. The program set up one hidden layer with twelve neurons. The output was the single neuron, B.L.10 strain. The facts were originally ordered sequentially as they occurred in flight, but they were randomized before presenting them for training. Networks learn most effectively when facts are presented randomly. [1]

The neural network was trained on 158 of the 159 facts in the definition file. One fact was discarded because it contradicted another fact, which was determined to have a more typical response. It was tested on 18 facts in the test file. (A listing of the definition and test files appear in Appendix A). The learning rate was set equal to 1.0 and the smoothing factor was 0.9, the program defaults. The network successfully trained on the 158 facts in approximately seventeen minutes, to within 10% tolerance. It successfully tested on the eighteen test cases within a 40% tolerance (a default of the program). The default tolerances will be tightened when more flights are available to train on. The defaults were acceptable for the proof of the concept, as gauged by the correlation coefficients. The correlation coefficient between the measured strains and the predicted strains at the B.L. 10 longeron was 0.97 for Flight 400 (Figure 2). Based on these results, the network was considered trained.

A forward stepwise regression was performed on the same variables used for the neural network analysis [2]. The following model was selected on the basis of its high correlation coefficient (0.96) to the measured B.L. 10 strains of Flight 400: Strain = 218.3*Nz - 9.2*AOA + 260.9*Mn - 229.9. The relationship between predicted and measured strains appears in Figure 3. Notice the neural network and the regression equation have a similar high level of correlation with the measured strains, based on the same data set. The measured and estimated strains for Flight 400 appear in Appendix B. Next, it was necessary to measure their predictive capabilities with the Flight 401 data.

RESULTS

The trained network was used to predict the B.L. 10 strains resulting from Nz peaks during Flight 401. There were 123 facts in the test file. The correlation coefficient between the predicted and measured strains at the B.L. 10 longeron was 0.93.

This relationship is shown in Figure 4. A listing of the test file for Flight 401 appears in Appendix C.

The predictive capability of the regression equation was also checked. The equation cited in the *ANALYSIS* section was used to predict the B.L. 10 strains occurring in Flight 401. The correlation coefficient between the predicted and measured strains was 0.94. This relationship is shown in Figure 5. There was no significant difference in the predictive capability of the regression equation over the neural network as determined by the value of the correlation coefficients. The measured and estimated strains from Flight 401 appear in Appendix D.

CONCLUSIONS

These preliminary results indicate that neural networks can be used to predict strains at critical locations. The neural network needs to train with several variables and facts to cover many maneuvers and points-in-the-sky.

More flight and strain data need to be made available so that a general network can trained. A neural network should be better at extrapolating beyond its training regime than a regression equation, and therefore, more useful. The example presented here worked well for both the regression and neural network approaches. There will be other cases that will be too complex for a regression approach, where the neural network will shine. These cases need to be identified so that the advantage of neural networks can be fully appreciated.

REFERENCES

1. *Brainmaker Professional*, v.2.02, User's Guide and Reference Manual, California Scientific Software, Grass Valley, CA 95945, 2nd Edition, Dec. 1990.

2. *SYSTAT*, v.5.0, Statistics Reference Manual, Systat, Inc., 1800 Sherman Avenue, Evanston, IL 60201-3793, 1990.

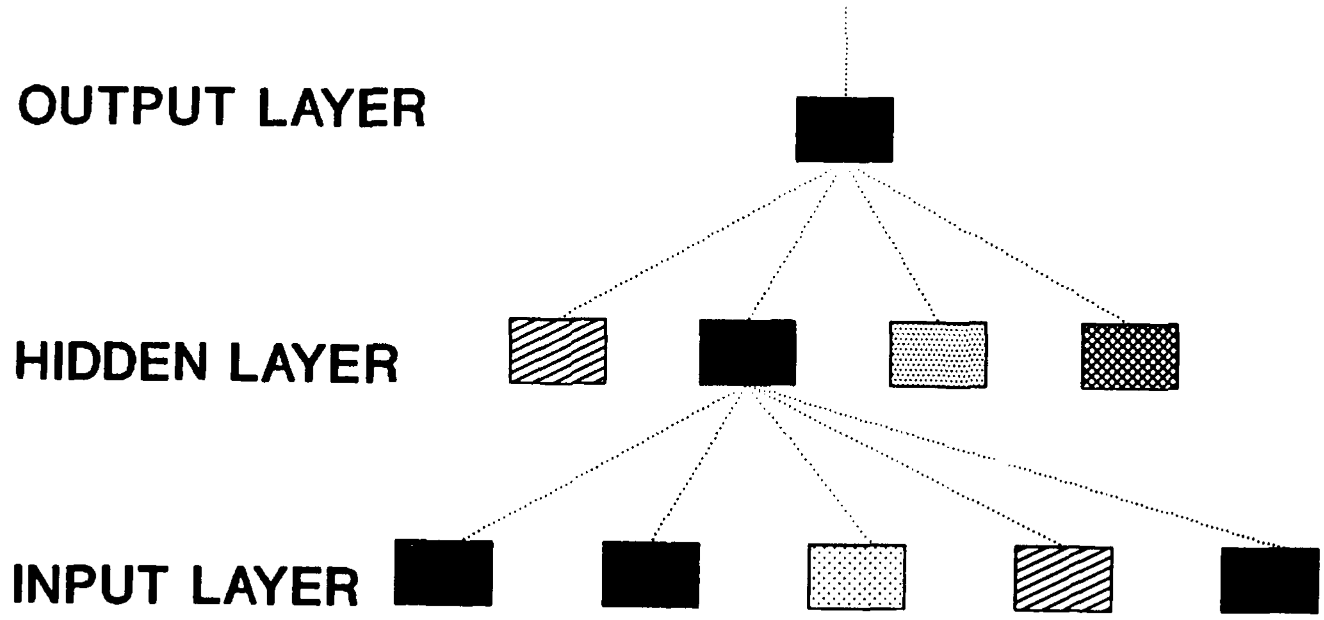

Figure 1. A sample neural network.

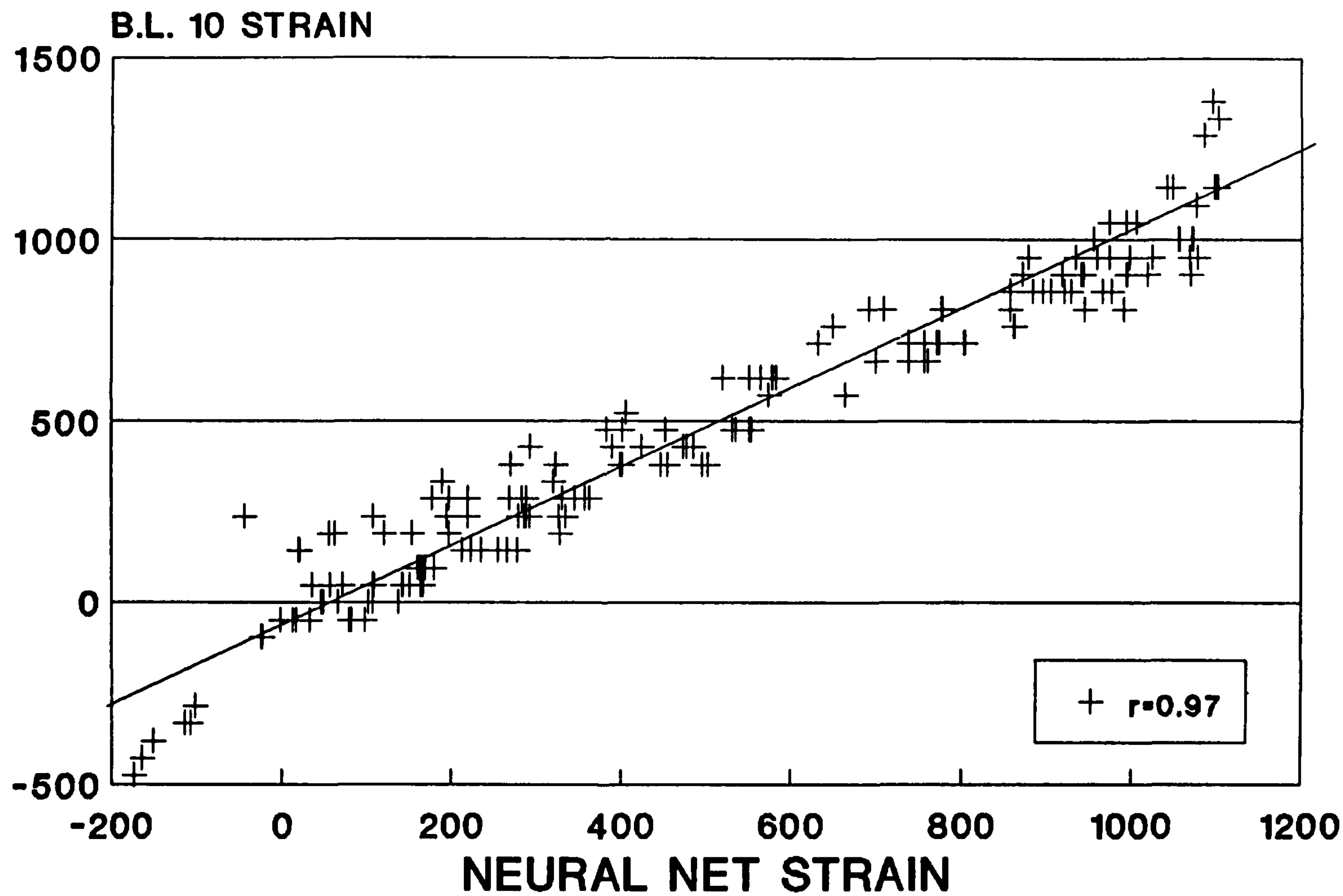

Figure 2. Linear regression of B.L. 10 strains measured during Flight 400 versus strains predicted from a neural network trained on Flight 400 data.

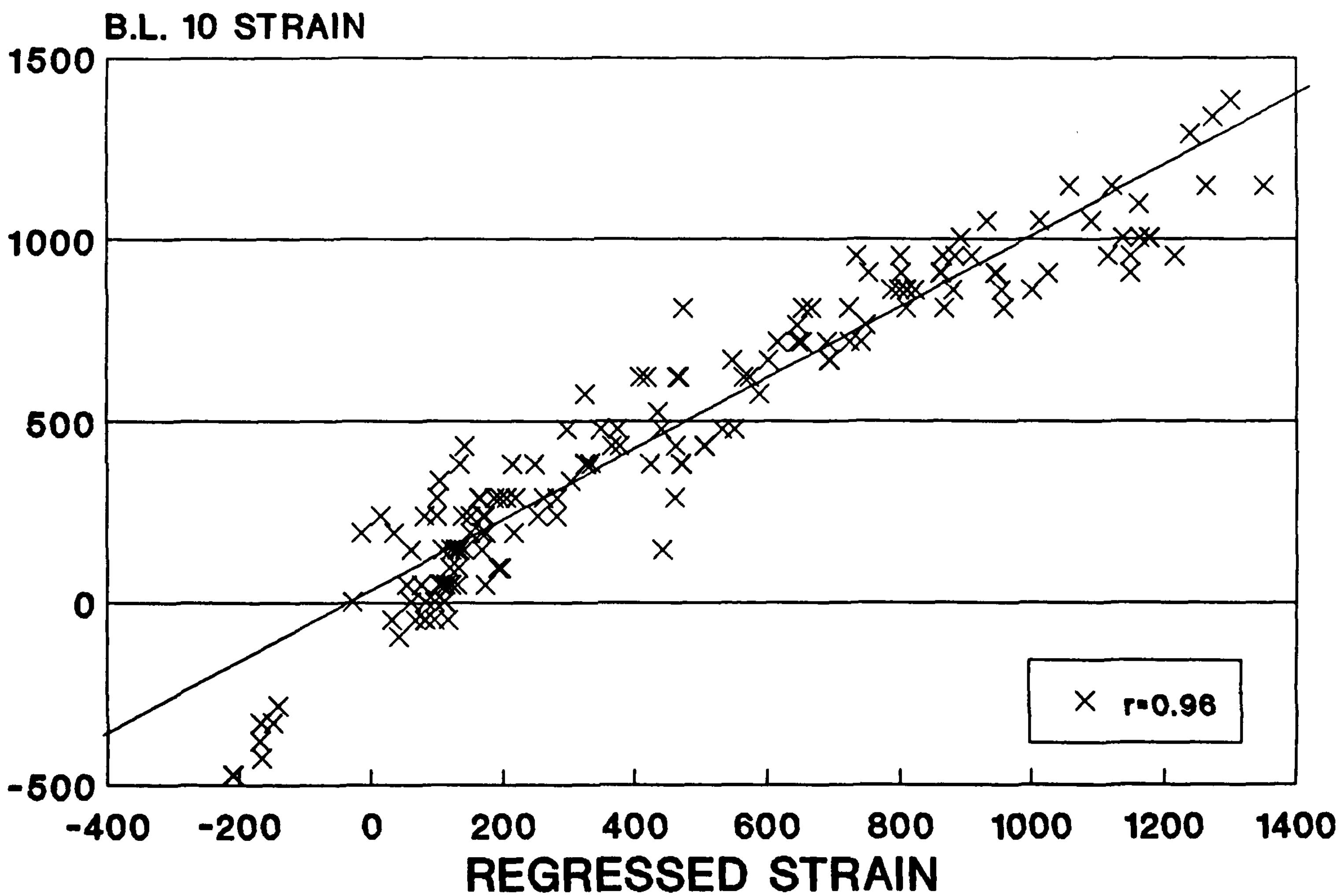

Figure 3. Linear regression of B.L. 10 strains measured from Flight 400 versus strains predicted from a forward-stepwise-regression on Flight 400 data.

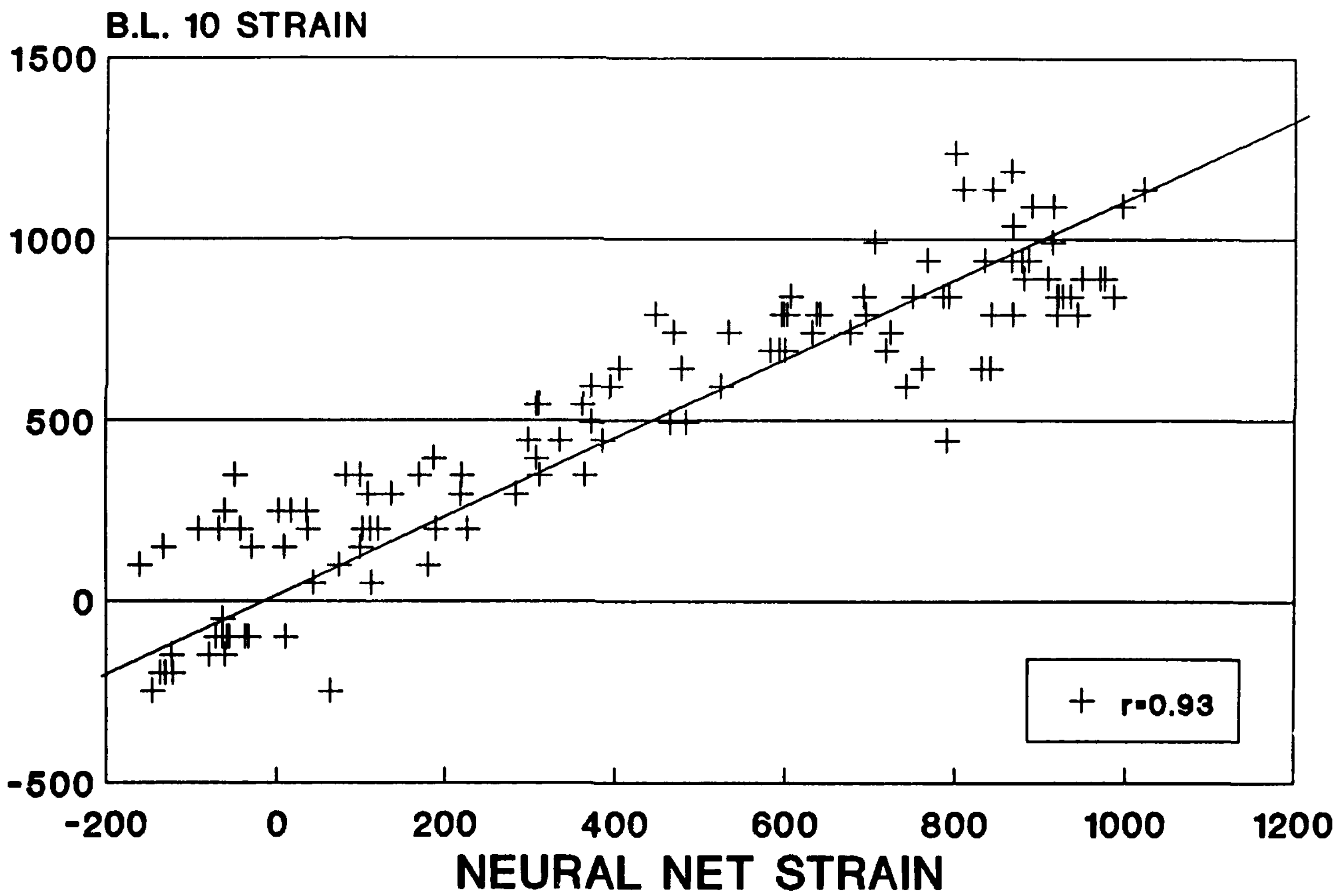

Figure 4. Linear regression of B.L. 10 strains measured during Flight 401 versus strains predicted from a neural network trained on Flight 400 data.

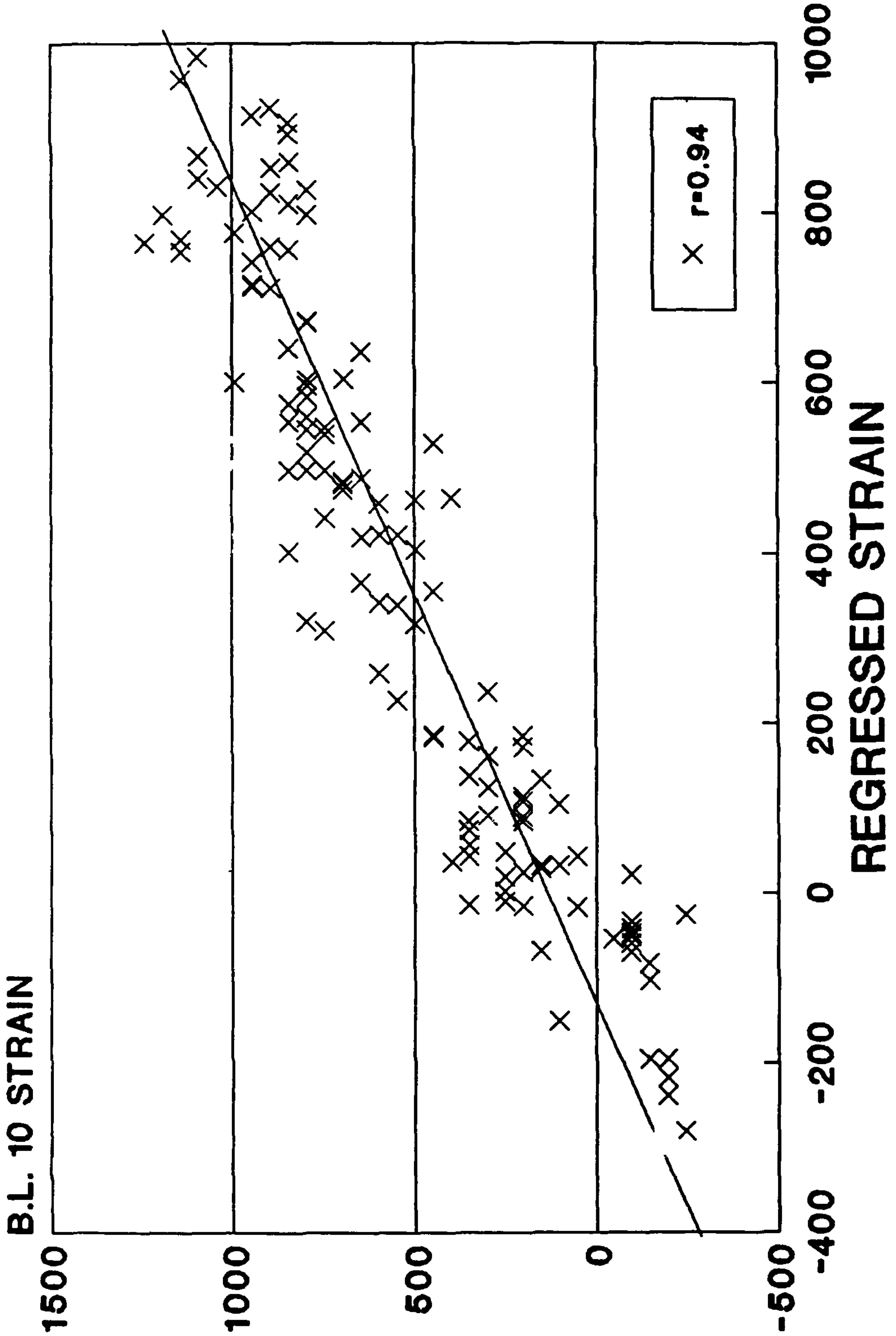

Figure 5. Linear regression of B.L. 10 strains measured during Flight 401 versus strains predicted from a forward-stepwise-regression on Flight 400 data.

APPENDIX A

APPENDIX A: THE DEFINITION FILE FOR FLIGHT 400.

The following pages contain the definition file for flight 400. The first ten lines of text tell the neural network what input and output variables will be used, the number of neurons in the hidden layer, and the display attributes. This file specifies 12 input neurons, one hidden layer with 12 hidden neurons, and one output neuron. The next set of lines dictate exactly how the neurons will be displayed on the screen. Following the display information, there is a line identifying the columns of input, and a line which identifies the output. The next four lines of data contain the minimum and maximum values of each variable. The values are selected by the program to include ninety percent of the data within their range for each column. These values are used to scale the data in each column to fall within the range of 0 to 1. The outlying five percent on either side are brought back into range at its endpoints. There is a line for the input, followed by a line for the output for both the minimum and maximum statements.

The facts are listed following the word "facts". The number of the fact is given as a comment for convenience, then a line of input appears. In this example, there is both numeric and symbolic input. The numeric input occurs first, followed by a left bracket and the symbolic data. The third line of each entry contains the output. There are 159 facts listed, fact 121 was commented out during training because it contradicted fact 99.

```
input number 1 12
  NZ  ACROLLRT  WNGSWEEP  AOA  MACHNO  ALTITUDE  P  T  V  L  False  True

output number 1 1
  BL1OSTR

hidden 12


display input   thermom 5 1 20 20 2
display output  thermom 5 25 3 10 3
display pattern thermom 6 25 3 10 3
display attribute bold 5 25 3 10 3
display screen   4 14
 NZ         ACROLLRT        BL1OSTR
                      Out:
 WNGSWEEP   AOA       Ptn:

 MACHNO     ALTITUDE

 P          T

 V          L

 False      True


     NZ ACROLLR WNGSWEE     AOA  MACHNO ALTITUD  P T V L False True
 BL1OSTR
minimum
-1.0826 -38.273   19.97  -10.23 0.46803 722.288  0 0 0 0 0 0
-225.16
maximum
5.78212 37.9936 64.4954 14.6917 1.00048   23837  1 1 1 1 1 1
1151.95
facts
ááááááááá 1
   6.22    2.48   60.59    6.88   0.896    7055  [  P  False
   1381
ááááááááá 2
   1.09       0   19.97   11.21    0.25     613  [  T  False
      0
ááááááááá 3
   1.39  -22.28   58.48   -4.82   0.882    7145  [  V  False
    476
ááááááááá 4
   2.86    2.48   19.97   13.16   0.395     893  [  P  False
    429
ááááááááá 5
   3.65    4.95   61.11   -0.49   0.905    6252  [  P  False
    857
ááááááááá 6
    0.5   34.65   57.95   -6.77   0.874    6830  [  V  False
    238
ááááááááá 7
   3.06       0   21.55   10.34   0.451    1806  [  P  False
    429
ááááááááá 8
   4.34    7.43   58.48    1.89   0.882    6785  [  P  False
```

1048
áááááááá 9
0.5 168.31 44.23 -3.09 0.782 16535 [V False
48
áááááááá 10
0.99 -2.48 56.37 -5.47 0.859 7625 [V False
286
áááááááá 11
2.17 -121.28 43.18 -1.57 0.769 17027 [P False
286
áááááááá 12
2.77 12.38 52.67 -1.14 0.829 8064 [P False
667
áááááááá 13
0.69 0 43.18 -4.82 0.773 17121 [V False
143
áááááááá 14
-1.08 0 46.34 -10.02 0.779 7809 [V False
-381
áááááááá 15
3.06 2.48 48.98 -0.27 0.801 6651 [P False
714
áááááááá 16
1.19 -19.8 52.67 -3.52 0.837 16596 [V False
238
áááááááá 17
0.4 0 46.34 -6.33 0.778 7304 [V False
48
áááááááá 18
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572
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857
áááááááá 20
0.5 7.43 22.08 -4.82 0.658 20935 [V False
0
áááááááá 21
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286
áááááááá 22
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667
áááááááá 23
3.26 0 48.45 0.16 0.793 5945 [P False
714
áááááááá 24
0.5 9.9 43.18 -5.9 0.751 7236 [V False
48
áááááááá 25
5.82 4.95 67.44 10.34 1.118 16322 [P False
1286
áááááááá 26
6.22 2.48 50.04 7.31 0.809 6808 [P False
1334
áááááááá 27
1.58 -44.55 67.44 -1.35 1.113 17090 [V False
619
áááááááá 28
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476
áááááááá 29
4.84 -2.48 67.44 6.88 1.12 13596 [P False
1143
áááááááá 30
6.22 2.48 50.04 7.31 0.809 6808 [P False
1334
áááááááá 31
0.5 17.33 67.44 -4.82 1.128 20012 [V False
286
áááááááá 32
1.98 0 48.98 -3.09 0.8 6897 [V False
476
áááááááá 33
4.54 2.48 48.98 2.76 0.798 5728 [P False
905
áááááááá 34
4.64 -4.95 48.45 12.51 0.821 20688 [V False
953
áááááááá 35
0.5 0 36.32 -5.9 0.698 9591 [V False
-48
áááááááá 36
5.82 -7.43 34.74 23.12 0.749 20688 [P False
905
áááááááá 37
2.17 -2.48 45.82 -2.44 0.776 7878 [P False
381
áááááááá 38
-1.08 -2.48 59 -10.23 0.884 21870 [V False
-286
áááááááá 39
0.79 0 46.34 -5.47 0.779 7936 [V False
95
áááááááá 40
3.06 0 63.75 3.84 0.925 20270 [P False
762
áááááááá 41
4.15 -4.95 48.45 2.54 0.796 7510 [P False
905
áááááááá 42
-0.98 0 37.9 -10.02 0.71 7809 [V False
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áááááááá 43
6.12 7.43 56.89 19 0.872 20235 [P False
1096
áááááááá 44
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476
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286
áááááááá 46
0.3 0 38.96 -6.33 0.715 7602 [V False
-48
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áááááááá 48
3.75 2.48 36.85 2.76 0.699 7625 [P False

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      762
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      -333
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         0
 áááááááá 53
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        48
 áááááááá 54
      6.32      2.48     48.98     23.55     0.821     20063   [   P   False
       953
 áááááááá 55
      6.41     -2.48     38.96     10.34     0.715      6307   [   P   False
      1143
 áááááááá 56
      0.69     -4.95     43.71      -4.6     0.801     20548   [   V   False
       238
 áááááááá 57
      1.58      2.48     37.38     -2.87     0.702      6429   [   V   False
       381
 áááááááá 58
      4.44         0     56.89      8.39     0.872     18328   [   P   False
      1000
 áááááááá 59
      3.65    -14.85     40.01      1.68     0.721      5771   [   P   False
       714
 áááááááá 60
     -1.08         0     25.25    -10.23     0.615      7602   [   V   False
      -476
 áááááááá 61
      2.67     -2.48     56.89      2.11     0.878     20723   [   P   False
       619
 áááááááá 62
      2.86         0     27.35      1.03     0.629      6362   [   P   False
       476
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        48
 áááááááá 64
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         0
 áááááááá 65
      3.55     -2.48     55.84      5.79     0.874     20970   [   P   False
       810
 áááááááá 66
      3.75         0     27.35      3.41     0.629      6274   [   P   False
       714
 áááááááá 67
      0.79     24.75     53.73     -4.17     0.853     21507   [   V   False
       286
 áááááááá 68
      0.99      -9.9     27.88     -4.17     0.635      6362   [   V   False
```

95
áááááááá 69
3.55 -2.48 30.52 2.54 0.653 5793 [P False
667
áááááááá 70
0.69 24.75 55.31 -4.39 0.862 21327 [V False
286
áááááááá 71
0.2 12.38 28.94 -6.55 0.638 6897 [V False
-95
áááááááá 72
4.34 4.95 58.48 9.04 0.881 20080 [P False
810
áááááááá 73
6.32 -4.95 25.25 14.45 0.607 5663 [P False
1000
áááááááá 74
1.09 44.55 55.84 -1.57 0.859 20566 [V False
381
áááááááá 75
1.78 -27.23 25.25 -1.57 0.61 5576 [V False
381
áááááááá 76
2.77 -4.95 53.2 2.76 0.85 20723 [P False
619
áááááááá 77
6.22 2.48 50.04 7.31 0.81 6808 [P False
1334
áááááááá 78
1.98 0 48.98 -3.09 0.8 6897 [V False
476
áááááááá 79
6.02 4.95 52.67 18.14 0.837 19468 [P False
1000
áááááááá 80
4.54 2.48 48.98 2.76 0.8 5728 [P False
905
áááááááá 81
0.69 42.08 42.65 -3.95 0.784 20759 [V False
286
áááááááá 82
0.5 0 36.32 -5.9 0.7 9591 [V False
-48
áááááááá 83
3.26 0 48.45 4.93 0.825 20166 [P False
810
áááááááá 84
2.17 -2.48 45.82 -2.44 0.78 7878 [P False
381
áááááááá 85
0.6 0 53.2 -5.47 0.852 21417 [V False
191
áááááááá 86
0.79 0 46.34 -5.47 0.78 7936 [V False
95
áááááááá 87
4.15 -4.95 48.45 2.54 0.8 7510 [P False
905
áááááááá 88
-1.08 0 52.15 -10.23 0.85 22238 [V False

-333
áááááááá 89
-0.98 0 37.9 -10.02 0.71 7809 [V False
-429
áááááááá 90
3.26 0 57.95 5.14 0.879 21041 [P False
810
áááááááá 91
2.57 -2.48 39.49 -1.35 0.72 7032 [P False
476
áááááááá 92
0.89 -4.95 46.34 -4.17 0.815 22799 [V False
191
áááááááá 93
0.3 0 38.96 -6.33 0.72 7602 [V False
-48
áááááááá 94
2.08 -2.48 50.56 0.81 0.835 22127 [P False
524
áááááááá 95
3.75 2.48 36.85 2.76 0.7 7625 [P False
762
áááááááá 96
1.19 -2.48 37.38 -3.95 0.71 7740 [V False
238
áááááááá 97
6.71 7.43 44.23 24.85 0.795 20566 [P False
953
áááááááá 98
2.47 -4.95 37.38 -1.35 0.7 7350 [P False
429
áááááááá 99
0.6 7.43 34.21 -4.82 0.752 20988 [V False
429
áááááááá 100
0.79 0 36.85 -5.04 0.7 7602 [V False
48
áááááááá 101
4.05 -2.48 43.18 8.17 0.789 19050 [P False
857
áááááááá 102
6.41 -2.48 38.96 10.34 0.72 6307 [P False
1143
áááááááá 103
0.1 0 41.07 -6.98 0.782 20374 [V False
0
áááááááá 104
1.58 2.48 37.38 -2.87 0.7 6429 [V False
381
áááááááá 105
3.65 -14.85 40.01 1.68 0.72 5771 [P False
714
áááááááá 106
0.4 -4.95 35.27 -5.69 0.755 20864 [V False
143
áááááááá 107
-1.08 0 25.25 -10.23 0.62 7602 [V False
-476
áááááááá 108
4.44 0 51.09 10.34 0.837 20287 [P False

953
áááááááá 109
2.86 0 27.35 1.03 0.63 6362 [P False
476
áááááááá 110
0.5 0 40.54 -5.47 0.781 21006 [V False
143
áááááááá 111
0.6 0 25.77 -5.25 0.62 6718 [V False
0
áááááááá 112
6.32 0 43.18 21.17 0.791 19350 [P False
1000
áááááááá 113
3.75 0 27.35 3.41 0.63 6274 [P False
714
áááááááá 114
0.99 -9.9 27.88 -4.17 0.64 6362 [V False
95
áááááááá 115
4.05 0 46.87 7.09 0.804 17655 [P False
953
áááááááá 116
3.55 -2.48 30.52 2.54 0.65 5793 [P False
667
áááááááá 117
0.89 0 37.9 -3.74 0.747 18037 [V False
286
áááááááá 118
0.2 12.38 28.94 -6.55 0.64 6897 [V False
-95
áááááááá 119
2.37 0 37.38 1.68 0.746 18231 [P False
619
áááááááá 120
6.32 -4.95 25.25 14.45 0.61 5663 [P False
1000
áááááááá 121
0 0 33.68 -7.2 0.747 21779 [V False
-48
áááááááá 122
1.78 -27.23 25.25 -1.57 0.61 5576 [V False
381
áááááááá 123
5.13 0 32.1 6.01 0.67 4671 [P False
1048
áááááááá 124
0.2 -9.9 21.55 -6.12 0.628 22573 [V False
191
áááááááá 125
0.4 0 25.25 -5.69 0.6 7925 [V False
-48
áááááááá 126
2.27 -61.88 21.55 -1.57 0.618 22724 [P False
143
áááááááá 127
4.24 0 29.99 4.93 0.65 7464 [P False
857
áááááááá 128
0.79 -79.21 21.55 -2.87 0.604 23256 [V False

143
áááááááá 129
0.5 0 27.35 -5.69 0.63 7717 [V False
-48
áááááááá 130
2.77 4.95 21.55 12.51 0.563 23759 [P False
619
áááááááá 131
4.24 0 26.3 5.58 0.62 7168 [P False
810
áááááááá 132
0.6 0 25.25 -5.25 0.61 7855 [V False
0
áááááááá 133
1.98 4.95 22.08 1.68 0.677 22387 [P False
429
áááááááá 134
2.37 0 24.19 1.24 0.56 7157 [P False
381
áááááááá 135
0.3 -2.48 25.77 -5.9 0.706 23837 [V False
48
áááááááá 136
0.5 2.48 67.44 -3.09 0.58 14284 [V False
143
áááááááá 137
2.37 0 32.63 2.11 0.744 22294 [P False
619
áááááááá 138
5.82 -2.48 67.44 14.45 0.69 5728 [P False
1048
áááááááá 139
0.79 0 27.35 -4.17 0.717 23141 [V False
238
áááááááá 140
0.69 2.48 67.44 -3.52 0.64 6241 [V False
143
áááááááá 141
5.82 -4.95 67.44 12.51 0.72 5858 [P False
953
áááááááá 142
1.58 -47.03 29.99 -2 0.729 20201 [V False
572
áááááááá 143
0.69 0 23.66 -4.39 0.55 9787 [V False
48
áááááááá 144
3.85 2.48 42.12 6.66 0.77 17136 [P False
905
áááááááá 145
5.43 4.95 67.44 13.59 0.64 1729 [P False
857
áááááááá 146
0.69 -9.9 22.61 -4.39 0.686 21797 [V False
143
áááááááá 147
0.69 2.48 19.97 0.16 0.25 529 [V False
191
áááááááá 148
5.62 -7.43 22.61 24.42 0.686 21417 [P False

857
áááááááá 149
1.09 4.95 19.97 -2.65 0.25 557 [L True
238
áááááááá 150
1.09 2.48 19.97 -0.7 0.25 566 [T False
238
áááááááá 151
2.17 2.48 21.55 3.84 0.63 22424 [P False
476
áááááááá 152
1.19 -2.48 19.97 -4.6 0.25 613 [L True
238
áááááááá 153
0.69 0 26.83 -4.6 0.716 22387 [V False
238
áááááááá 154
1.19 0 19.97 -0.27 0.25 576 [T False
286
áááááááá 155
4.74 2.48 31.57 12.94 0.735 21616 [P False
857
áááááááá 156
2.17 2.48 19.97 10.56 0.25 557 [P False
381
áááááááá 157
2.67 126.24 26.3 6.66 0.686 20900 [V False
810
áááááááá 158
1.78 4.95 19.97 9.91 0.25 520 [L True
381
áááááááá 159
0.2 0 22.61 -6.33 0.693 20829 [V False
48

facts
áááááááá 160
1.19 0 21.03 -0.7 0.433 1652 [V False
191
áááááááá 161
3.16 0 52.67 3.63 0.841 16504 [P False
714
áááááááá 162
0.89 -2.48 66.92 -3.52 1.148 22275 [V False
476
áááááááá 163
6.91 4.95 64.28 18.79 0.93 19687 [P False
1143
áááááááá 164
0.5 2.48 60.59 -5.9 0.895 21220 [V False
191
áááááááá 165
2.96 0 61.11 4.06 0.902 20270 [P False
714
áááááááá 166
0.4 2.48 49.51 -6.12 0.832 21291 [V False
95
áááááááá 167
4.05 -2.48 58.48 8.17 0.882 20794 [P False
857
áááááááá 168
1.29 -76.73 52.15 -3.09 0.849 20864 [V False
333
áááááááá 169
4.05 0 57.95 9.04 0.879 21363 [P False
905
áááááááá 170
0.3 -2.48 44.76 -6.12 0.802 22686 [V False
48
áááááááá 171
6.32 2.48 46.87 23.12 0.804 19451 [P False
905
áááááááá 172
0.4 -12.38 40.01 -4.82 0.77 19687 [V False
333
áááááááá 173
5.62 -4.95 29.46 24.85 0.712 21113 [P False
810
áááááááá 174
0.69 0 21.55 -3.52 0.629 22761 [V False
95
áááááááá 175
6.32 2.48 27.35 23.55 0.715 20653 [P False
1143
áááááááá 176
0.2 44.55 21.55 -5.47 0.573 22686 [V False
238
áááááááá 177
3.75 0 35.79 5.79 0.752 19199 [P False
953

APPENDIX B

APPENDIX B: The measured and predicted B.L 10 strains for Flight 400.

The following pages contain a listing of the 177 peak and valley B.L. 10 strains which occurred during Flight 400. Three strains are shown. The first (BL10STR) is the strain that was recorded by the SDRS system, the second (NETSTRAI) is the strain predicted by the trained neural network, and the third (STNEST) is the strain calculated from the regression equation: BL10STR= 218.3*Nz - 9.2*AOA + 260.9*MACHNO - 229.9. These data are plotted in Figures 2 and 3 of the paper.

		BL10STR	NETSTRAI	STNEST
CASE	1	0.000	106.130	-29.542
CASE	2	429.000	423.840	376.731
CASE	3	191.000	120.250	149.200
CASE	4	429.000	471.920	460.842
CASE	5	48.000	163.620	111.548
CASE	6	286.000	177.070	458.721
CASE	7	143.000	255.070	166.529
CASE	8	714.000	756.020	645.913
CASE	9	238.000	335.080	280.438
CASE	10	572.000	663.560	587.557
CASE	11	0.000	137.390	95.061
CASE	12	667.000	737.190	545.420
CASE	13	476.000	450.740	296.086
CASE	14	1286.000	1085.100	1237.237
CASE	15	619.000	577.490	417.664
CASE	16	1143.000	1040.700	1055.580
CASE	17	286.000	362.650	217.664
CASE	18	1143.000	1099.900	1348.640
CASE	19	953.000	1023.900	882.321
CASE	20	905.000	1018.200	1023.826
CASE	21	-286.000	-102.900	-141.246
CASE	22	762.000	649.100	644.074
CASE	23	191.000	152.520	166.784
CASE	24	1096.000	1075.400	1159.159
CASE	25	286.000	219.430	163.059
CASE	26	953.000	973.540	906.842
CASE	27	-333.000	-114.400	-168.289
CASE	28	714.000	631.280	614.231

CASE	29	0.000	65.114	81.223
CASE	30	953.000	1067.300	1147.797
CASE	31	238.000	278.940	171.816
CASE	32	1000.000	954.040	889.740
CASE	33	95.000	161.940	130.541
CASE	34	619.000	550.260	562.550
CASE	35	48.000	107.140	120.482
CASE	36	810.000	775.180	719.843
CASE	37	286.000	331.050	203.265
CASE	38	857.000	856.880	809.243
CASE	39	286.000	287.680	185.804
CASE	40	810.000	943.960	864.303
CASE	41	381.000	501.840	246.475
CASE	42	619.000	578.160	571.114
CASE	43	333.000	319.960	301.452
CASE	44	1000.000	1070.700	1136.086
CASE	45	286.000	345.510	161.423
CASE	46	810.000	777.530	651.649
CASE	47	191.000	197.240	173.452
CASE	48	905.000	870.660	800.486
CASE	49	-333.000	-108.000	-150.115
CASE	50	810.000	707.940	663.810
CASE	51	191.000	327.690	215.179
CASE	52	524.000	405.020	434.476
CASE	53	48.000	149.830	100.889
CASE	54	953.000	1076.700	1214.220
CASE	55	429.000	291.710	141.407
CASE	56	857.000	920.420	784.984
CASE	57	0.000	102.090	59.903
CASE	58	905.000	1068.000	1147.305
CASE	59	143.000	212.370	106.513
CASE	60	953.000	959.090	862.735
CASE	61	143.000	234.890	133.105
CASE	62	1000.000	1070.300	1161.789
CASE	63	333.000	188.830	102.450
CASE	64	953.000	933.540	798.797
CASE	65	286.000	356.600	193.499
CASE	66	619.000	582.530	466.580
CASE	67	-48.000	97.390	30.963
CASE	68	810.000	990.020	954.663
CASE	69	191.000	55.027	33.673
CASE	70	143.000	278.270	441.157
CASE	71	143.000	223.130	126.395
CASE	72	619.000	518.990	406.870
CASE	73	95.000	179.760	117.048
CASE	74	429.000	389.210	363.459
CASE	75	48.000	166.980	73.830
CASE	76	619.000	563.710	462.117
CASE	77	238.000	326.340	167.789
CASE	78	1143.000	1047.500	1120.146
CASE	79	572.000	573.460	323.453
CASE	80	905.000	918.070	750.217
CASE	81	143.000	265.150	139.892
CASE	82	857.000	975.230	951.823
CASE	83	238.000	-44.150	13.368
CASE	84	476.000	381.820	372.868

CASE	85	238.000	292.050	149.643
CASE	86	857.000	964.800	877.772
CASE	87	810.000	690.790	470.756
CASE	88	953.000	877.720	731.671
CASE	89	48.000	108.140	52.554
CASE	90	1381.000	1094.500	1298.349
CASE	91	476.000	401.320	347.746
CASE	92	857.000	882.770	807.325
CASE	93	238.000	106.130	169.281
CASE	94	1048.000	973.540	930.108
CASE	95	286.000	268.850	260.400
CASE	96	667.000	698.860	601.387
CASE	97	-381.000	-151.700	-170.561
CASE	98	714.000	736.850	649.404
CASE	99	48.000	56.708	118.379
CASE	100	857.000	904.290	796.813
CASE	101	286.000	282.640	281.399
CASE	102	714.000	770.140	687.028
CASE	103	48.000	70.829	129.221
CASE	104	1334.000	1101.300	1271.713
CASE	105	476.000	550.590	439.271
CASE	106	1334.000	1101.300	1271.713
CASE	107	476.000	550.590	439.271
CASE	108	905.000	993.380	943.873
CASE	109	-48.000	79.234	115.395
CASE	110	381.000	446.370	468.522
CASE	111	95.000	167.320	195.879
CASE	112	905.000	939.920	860.246
CASE	113	-429.000	-164.500	-166.734
CASE	114	476.000	534.120	531.748
CASE	115	-48.000	12.665	80.119
CASE	116	762.000	860.580	745.621
CASE	117	238.000	286.000	250.990
CASE	118	429.000	483.690	505.227
CASE	119	48.000	141.760	171.068
CASE	120	1143.000	1095.900	1260.886
CASE	121	381.000	400.310	324.386
CASE	122	714.000	803.090	739.434
CASE	123	-476.000	-174.600	-211.417
CASE	124	476.000	551.600	548.967
CASE	125	0.000	45.277	109.872
CASE	126	714.000	770.470	721.403
CASE	127	95.000	160.260	190.051
CASE	128	667.000	760.050	691.986
CASE	129	-95.000	-24.310	40.224
CASE	130	1000.000	1054.200	1175.393
CASE	131	381.000	401.320	332.122
CASE	132	1334.000	1101.600	1271.974
CASE	133	476.000	550.590	439.271
CASE	134	905.000	994.730	944.395
CASE	135	-48.000	80.915	115.917
CASE	136	381.000	453.430	469.565
CASE	137	95.000	168.330	196.140
CASE	138	905.000	942.950	861.290
CASE	139	-429.000	-164.500	-166.734
CASE	140	476.000	530.090	531.227

CASE	141	-48.000	16.027	81.423
CASE	142	762.000	862.260	745.882
CASE	143	238.000	287.680	251.251
CASE	144	429.000	476.630	504.183
CASE	145	48.000	142.440	171.329
CASE	146	1143.000	1097.200	1262.190
CASE	147	381.000	397.960	323.864
CASE	148	714.000	801.740	739.174
CASE	149	-476.000	-174.200	-210.113
CASE	150	476.000	552.950	549.228
CASE	151	0.000	47.967	110.916
CASE	152	714.000	772.490	721.664
CASE	153	95.000	165.640	191.355
CASE	154	667.000	755.350	691.204
CASE	155	-95.000	-23.640	40.745
CASE	156	1000.000	1055.500	1176.176
CASE	157	381.000	401.320	332.122
CASE	158	1048.000	1005.100	1009.465
CASE	159	-48.000	-1.455	66.080
CASE	160	857.000	894.540	819.895
CASE	161	-48.000	33.174	95.732
CASE	162	810.000	856.880	806.111
CASE	163	0.000	45.950	108.307
CASE	164	381.000	322.310	422.094
CASE	165	143.000	18.717	58.855
CASE	166	1048.000	993.380	1087.914
CASE	167	143.000	20.734	119.918
CASE	168	953.000	997.080	1113.523
CASE	169	48.000	35.191	104.416
CASE	170	857.000	928.490	997.632
CASE	171	191.000	61.415	-15.551
CASE	172	238.000	219.430	97.513
CASE	173	238.000	193.540	79.637
CASE	174	238.000	194.210	137.214
CASE	175	286.000	196.230	97.521
CASE	176	381.000	269.520	212.140
CASE	177	381.000	495.460	132.976

APPENDIX C

APPENDIX C: THE TEST FILES FOR FLIGHT 401.

The following pages contain the testing facts for flight 401. Following the word "facts", the facts are listed. The number of the fact is given as a comment for convenience, then a line of input appears. In this example, there is both numeric and symbolic input. The numeric input occurs first, followed by a left bracket and the symbolic data. The third line of each entry contains the output. They appear in the same order as dictated by the definition file which appears in Appendix A. One hundred twenty-three facts are listed.

facts

ááááááááá1									
1.19	2.48	19.97	12.29	0.25	837	[	T	False	
50									
ááááááááá2									
2.67	0	19.97	11.42	0.41	1166	[	P	False	
446									
ááááááááá3									
0.3	12.38	19.97	-2.87	0.33	6076	[	V	False	
-99									
ááááááááá4									
2.17	-131.19	45.29	-2	0.77	16020	[	P	False	
396									
ááááááááá5									
0.69	-2.48	46.87	-4.82	0.79	16020	[	V	False	
198									
ááááááááá6									
3.16	2.48	49.51	3.41	0.81	15308	[	P	False	
842									
ááááááááá7									
0.99	-14.85	50.04	-4.17	0.81	15308	[	V	False	
297									
ááááááááá8									
2.96	0	50.56	2.54	0.81	14284	[	P	False	
694									
ááááááááá9									
0.1	160.89	28.41	-4.17	0.73	20794	[	V	False	
-99									
ááááááááá10									
2.08	-2.48	31.05	1.24	0.73	20391	[	P	False	
495									
ááááááááá11									
-0.19	-160.89	28.41	-6.12	0.72	20988	[	V	False	
-248									
ááááááááá12									
2.67	2.48	45.29	2.76	0.81	19417	[	P	False	
743									
ááááááááá13									
-0.09	185.64	58.48	-6.77	0.88	20759	[	V	False	
50									
ááááááááá14									
2.08	-2.48	61.11	0.16	0.9	20322	[	P	False	
594									
ááááááááá15									
-0.59	0	24.72	-10.02	0.7	21220	[	V	False	
-149									
ááááááááá16									
2.57	0	31.57	2.76	0.73	19552	[	P	False	
743									
ááááááááá17									
-0.69	0	25.25	-10.23	0.7	20478	[	V	False	
-149									
ááááááááá18									
2.57	0	25.77	3.41	0.7	19670	[	P	False	
694									
ááááááááá19									
0.5	0	23.14	-5.25	0.69	20601	[	V	False	
198									
ááááááááá20									
4.24	-2.48	27.35	13.16	0.71	19806	[	P	False	

```
892
ááááááááá21
0.69 -27.23 25.77 -3.52 0.7 20080 [ V False
347
ááááááááá22
4.54 -2.48 29.46 13.16 0.71 19266 [ P False
793
ááááááááá23
0.89 29.7 28.94 -3.52 0.71 19535 [ V False
446
ááááááááá24
2.47 -2.48 31.05 2.54 0.72 18785 [ P False
694
ááááááááá25
-0.59 2.48 37.9 -9.8 0.76 20409 [ V False
-99
ááááááááá26
2.77 0 42.65 2.98 0.79 19283 [ P False
842
ááááááááá27
-0.49 0 35.79 -9.8 0.76 20935 [ V False
-99
ááááááááá28
2.77 0 38.43 3.41 0.77 20080 [ P False
793
ááááááááá29
0.79 14.85 35.79 -3.95 0.76 20847 [ V False
347
ááááááááá30
4.93 0 33.16 15.97 0.74 20478 [ P False
842
ááááááááá31
1.29 -7.43 29.46 -1.79 0.73 20970 [ V False
594
ááááááááá32
4.74 2.48 29.46 15.32 0.72 20235 [ P False
892
ááááááááá33
0.89 19.8 27.88 -3.52 0.72 20653 [ V False
446
ááááááááá34
2.57 0 32.63 2.98 0.74 19943 [ P False
793
ááááááááá35
-0.69 -2.48 56.89 -10.23 0.87 20759 [ V False
-99
ááááááááá36
2.77 0 61.64 3.19 0.91 19670 [ P False
793
ááááááááá37
-0.59 2.48 53.73 -10.23 0.85 20759 [ V False
-99
ááááááááá38
2.77 0 56.37 2.98 0.87 20080 [ P False
842
ááááááááá39
0.3 -2.48 51.09 -6.33 0.84 20917 [ V False
198
ááááááááá40
4.34 0 60.59 9.47 0.9 20149 [ P False
```

1090
ááááááááá41
2.27 -27.23 59 1.89 0.89 20132 [V False
694
ááááááááá42
4.84 14.85 61.11 11.42 0.9 19050 [P False
1139
ááááááááá43
0.89 14.85 58.48 -3.52 0.88 19535 [V False
545
ááááááááá44
3.46 0 62.17 5.14 0.91 18118 [P False
941
ááááááááá45
-0.69 2.48 59.53 -10.23 0.89 20601 [V False
-50
ááááááááá46
2.77 0 63.75 2.33 0.93 19789 [P False
793
ááááááááá47
-0.59 2.48 58.48 -10.23 0.88 20917 [V False
-99
ááááááááá48
2.57 0 61.64 2.33 0.91 20548 [P False
743
ááááááááá49
0.3 -2.48 59.53 -6.98 0.89 21327 [V False
149
ááááááááá50
4.15 0 62.7 9.04 0.91 20723 [P False
1040
ááááááááá51
1.98 -138.61 61.64 -2.44 0.91 21435 [V False
495
ááááááááá52
4.15 2.48 63.22 8.39 0.92 19620 [P False
1090
ááááááááá53
1.29 0 61.11 -3.3 0.9 19789 [V False
495
ááááááááá54
2.77 -2.48 64.81 1.89 0.94 18752 [P False
793
ááááááááá55
0.5 0 22.08 -5.04 0.68 21327 [V False
99
ááááááááá56
4.44 4.95 21.55 24.63 0.6 22035 [P False
793
ááááááááá57
0.6 -9.9 21.03 -3.09 0.55 20601 [V False
347
ááááááááá58
3.16 0 22.08 10.56 0.59 18802 [P False
793
ááááááááá59
0.3 -24.75 21.55 -4.6 0.59 23294 [V False
99
ááááááááá60
4.44 0 21.55 24.42 0.6 22517 [P False

793
ááááááááá61
0.5 -27.23 21.03 -3.3 0.56 21220 [V False
347
ááááááááá62
3.36 0 23.66 7.74 0.64 19183 [P False
991
ááááááááá63
0.5 2.48 22.08 -4.82 0.63 20953 [V False
198
ááááááááá64
3.65 -2.48 21.55 24.85 0.57 21399 [P False
644
ááááááááá65
0.1 -4.95 21.03 -6.33 0.51 22220 [V False
198
ááááááááá66
2.27 0 21.03 7.74 0.56 20917 [P False
594
ááááááááá67
0.69 0 21.55 -2.44 0.56 20794 [V False
297
ááááááááá68
3.36 0 21.55 24.63 0.55 20864 [P False
594
ááááááááá69
0.1 2.48 21.03 -6.98 0.49 21489 [V False
198
ááááááááá70
5.33 2.48 21.55 23.98 0.56 21024 [P False
842
ááááááááá71
-0.19 -2.48 20.5 -8.72 0.47 21006 [V False
149
ááááááááá72
5.53 -4.95 21.55 23.98 0.57 21077 [P False
842
ááááááááá73
-0.59 4.95 20.5 -9.8 0.45 21399 [V False
99
ááááááááá74
1.98 4.95 24.72 1.24 0.67 19066 [P False
644
ááááááááá75
-1.18 0 22.61 -10.23 0.67 20917 [V False
-198
ááááááááá76
4.54 0 24.19 16.84 0.65 18983 [P False
991
ááááááááá77
-1.28 2.48 22.08 -10.23 0.67 21291 [V False
-198
ááááááááá78
5.03 -2.48 22.61 24.85 0.65 20201 [P False
842
ááááááááá79
-0.09 0 22.08 -8.28 0.61 20759 [V False
347
ááááááááá80
4.05 9.9 21.55 24.42 0.47 13763 [P False

644
ááááááááá81
0.4 19.8 22.08 -4.17 0.49 17308 [V False
198
ááááááááá82
4.44 2.48 22.08 24.42 0.46 15103 [P False
644
ááááááááá83
3.36 2.48 22.08 24.85 0.48 14284 [V False
842
ááááááááá84
5.23 4.95 23.14 24.63 0.53 12399 [P False
892
ááááááááá85
-1.08 0 22.08 -10.23 0.67 21399 [V False
-149
ááááááááá86
4.05 0 23.14 12.94 0.68 19994 [P False
941
ááááááááá87
-1.47 2.48 22.08 -10.23 0.67 21706 [V False
-248
ááááááááá88
4.24 2.48 22.08 17.05 0.66 20566 [P False
892
ááááááááá89
0.1 0 21.55 -6.98 0.62 21471 [V False
248
ááááááááá90
5.82 -2.48 22.61 24.85 0.65 19300 [P False
1090
ááááááááá91
2.47 -17.33 19.97 10.56 0.41 9251 [V False
793
ááááááááá92
4.44 0 22.61 12.07 0.52 7418 [P False
1238
ááááááááá93
0.5 79.21 20.5 -0.7 0.44 16382 [V False
248
ááááááááá94
3.95 4.95 21.55 24.2 0.45 16413 [P False
446
ááááááááá95
0.5 2.48 19.97 -1.79 0.36 12802 [V False
248
ááááááááá96
5.13 -2.48 22.61 24.63 0.51 13128 [P False
793
ááááááááá97
-1.18 0 22.08 -10.23 0.67 21238 [V False
-198
ááááááááá98
4.44 -4.95 22.61 12.29 0.67 20012 [P False
941
ááááááááá99
0.2 -2.48 22.08 -7.2 0.64 20900 [V False
248
ááááááááá100
5.53 7.43 22.08 24.42 0.65 22461 [P False

```
   892
ááááááááá101
  3.75   12.38   21.03   24.63    0.51   19350  [  V  False
   842
ááááááááá102
  4.93   14.85   22.61   24.42    0.51   15455  [  P  False
   842
ááááááááá103
  2.08   -29.7   22.61    4.71    0.49   12506  [  V  False
   743
ááááááááá104
  4.24       0   24.19    9.69    0.56   11220  [  P  False
  1139
ááááááááá105
  0.79       0   22.61   -3.09    0.58   18719  [  V  False
   297
ááááááááá106
  2.08       0   22.08    4.06    0.58   19384  [  P  False
   545
ááááááááá107
   0.5    2.48   21.55    -4.6    0.62   21273  [  V  False
   198
ááááááááá108
  2.96       0   22.08    3.84    0.68   20444  [  P  False
   793
ááááááááá109
  0.79   17.33   22.08   -4.39    0.68   21255  [  V  False
   297
ááááááááá110
  4.15   -4.95   22.08    9.26    0.68   20794  [  P  False
  1139
ááááááááá111
  2.37       0   22.08    2.33    0.67   21184  [  V  False
   743
ááááááááá112
  4.34   -4.95   22.08   10.34    0.67   20305  [  P  False
  1189
ááááááááá113
 -1.08       0   22.08  -10.23    0.67   21616  [  V  False
  -198
ááááááááá114
  4.34   -7.43   22.08   15.54    0.64   20688  [  P  False
   941
ááááááááá115
   0.3       0   21.55   -5.04    0.56   22875  [  V  False
   149
ááááááááá116
  2.08    4.95   31.05    -0.7    0.72   18950  [  P  False
   644
ááááááááá117
   0.5   12.38   21.55   -3.52    0.46   11207  [  V  False
   149
ááááááááá118
  2.67       0   67.44    7.96    0.54    2077  [  P  False
   545
ááááááááá119
  0.99   -2.48   67.44    -3.3    0.64    1864  [  V  False
   198
ááááááááá120
  5.13       0   67.44   14.45     0.6    1585  [  P  False
```

941
áááááááá121
1.39 -7.43 19.97 11.21 0.25 837 [L True
396
áááááááá122
1.39 0 19.97 6.01 0.25 818 [T False
347
áááááááá123
0.99 0 19.97 1.03 0.25 790 [L True
347

APPENDIX D

APPENDIX D: The measured and predicted B.L 10 strains for Flight 401.

The following pages contain a listing of the 123 peak and valley B.L. 10 strains which occurred during Flight 401. Three strains are shown. The first (BL10STR) is the strain that was recorded by the SDRS system, the second (NETSTRAI) is the strain predicted by the trained neural network, and the third (STNEST) is the strain calculated from the regression equation: BL10STR= 218.3*Nz - 9.2*AOA + 260.9*MACHNO - 229.9. These data are plotted in Figures 4 and 5 of the paper.

		BL10STR	NETSTRAI	STNEST
CASE	1	50.000	112.510	-17.616
CASE	2	446.000	385.520	355.124
CASE	3	-99.000	-38.100	-52.029
CASE	4	396.000	186.820	462.923
CASE	5	198.000	226.490	170.964
CASE	6	842.000	785.600	639.843
CASE	7	297.000	283.310	235.701
CASE	8	694.000	717.690	604.166
CASE	9	-99.000	10.648	20.579
CASE	10	495.000	483.350	403.144
CASE	11	-248.000	62.760	-27.450
CASE	12	743.000	675.330	538.854
CASE	13	50.000	42.924	42.072
CASE	14	594.000	392.910	457.390
CASE	15	-149.000	-61.970	-84.221
CASE	16	743.000	630.610	496.159
CASE	17	-149.000	-79.450	-104.122
CASE	18	694.000	597.660	482.374
CASE	19	198.000	189.510	107.350
CASE	20	892.000	907.980	760.102
CASE	21	347.000	310.210	135.569
CASE	22	793.000	943.290	825.581
CASE	23	446.000	297.090	181.830
CASE	24	694.000	591.950	473.741
CASE	25	-99.000	-55.920	-70.586
CASE	26	842.000	690.790	553.446
CASE	27	-99.000	-33.730	-48.760
CASE	28	793.000	694.160	544.287
CASE	29	347.000	364.330	176.989
CASE	30	842.000	985.310	892.770
CASE	31	594.000	522.350	258.493
CASE	32	892.000	969.510	852.041
CASE	33	446.000	334.410	184.439
CASE	34	793.000	639.020	496.751
CASE	35	-99.000	-71.720	-59.776
CASE	36	793.000	596.650	582.824
CASE	37	-99.000	-64.660	-43.167
CASE	38	842.000	605.060	574.315
CASE	39	198.000	119.570	112.726
CASE	40	1090.000	915.380	865.318
CASE	41	694.000	580.850	480.393

CASE	42	1139.000	1021.200	956.573
CASE	43	545.000	306.510	226.176
CASE	44	941.000	766.780	715.549
CASE	45	-50.000	-64.660	-54.559
CASE	46	793.000	593.970	595.925
CASE	47	-99.000	-58.270	-35.341
CASE	48	743.000	532.100	547.055
CASE	49	149.000	98.398	131.728
CASE	50	1040.000	867.300	830.398
CASE	51	495.000	464.520	462.007
CASE	52	1090.000	889.830	838.966
CASE	53	495.000	371.060	316.681
CASE	54	793.000	600.350	602.567
CASE	55	99.000	179.420	102.816
CASE	56	793.000	867.640	669.915
CASE	57	347.000	81.924	72.855
CASE	58	793.000	635.320	516.911
CASE	59	99.000	74.191	31.653
CASE	60	793.000	842.090	671.840
CASE	61	347.000	98.398	55.563
CASE	62	991.000	704.580	599.457
CASE	63	198.000	111.170	87.756
CASE	64	644.000	759.720	487.645
CASE	65	198.000	-68.360	-17.009
CASE	66	594.000	369.710	340.683
CASE	67	297.000	107.470	89.149
CASE	68	594.000	740.890	421.149
CASE	69	198.000	-91.550	-16.268
CASE	70	842.000	919.750	859.692
CASE	71	149.000	-132.900	-68.830
CASE	72	842.000	918.740	905.953
CASE	73	99.000	-160.800	-151.452
CASE	74	644.000	403.000	365.667
CASE	75	-198.000	-131.900	-218.896
CASE	76	991.000	913.030	776.195
CASE	77	-198.000	-137.200	-240.722
CASE	78	842.000	934.540	809.716
CASE	79	347.000	-49.860	-14.517
CASE	80	644.000	830.660	552.806
CASE	81	198.000	-42.470	23.452
CASE	82	644.000	840.070	635.320
CASE	83	842.000	749.290	400.872
CASE	84	892.000	947.990	824.082
CASE	85	-149.000	-123.400	-197.070
CASE	86	941.000	866.290	712.824
CASE	87	-248.000	-146.600	-282.192
CASE	88	892.000	880.750	711.400
CASE	89	248.000	1.907	17.644
CASE	90	1090.000	996.070	982.143
CASE	91	793.000	445.700	319.355
CASE	92	1238.000	799.720	764.184
CASE	93	248.000	16.700	0.425
CASE	94	446.000	790.980	527.780
CASE	95	248.000	-60.960	-10.451
CASE	96	793.000	919.410	797.038
CASE	97	-198.000	-130.800	-218.896

CASE	98	941.000	885.120	801.296
CASE	99	248.000	35.527	46.704
CASE	100	892.000	974.890	922.788
CASE	101	842.000	791.660	495.837
CASE	102	842.000	925.470	755.311
CASE	103	743.000	467.210	308.729
CASE	104	1139.000	808.470	752.783
CASE	105	297.000	135.710	122.151
CASE	106	545.000	309.870	338.165
CASE	107	198.000	101.760	83.131
CASE	108	793.000	635.650	558.338
CASE	109	297.000	217.750	160.154
CASE	110	1139.000	843.430	768.384
CASE	111	743.000	722.730	440.797
CASE	112	1189.000	866.290	797.345
CASE	113	-198.000	-122.400	-197.070
CASE	114	941.000	834.020	741.851
CASE	115	149.000	8.295	27.861
CASE	116	644.000	475.960	418.320
CASE	117	149.000	-30.030	31.494
CASE	118	545.000	360.640	420.754
CASE	119	198.000	36.200	183.380
CASE	120	941.000	877.720	913.836
CASE	121	396.000	306.170	35.937
CASE	122	347.000	169.330	83.605
CASE	123	347.000	219.090	41.952